Analog television

- Introduction
- Analog TV systems
- Progressive and interlaced systems
- Synchronism signals
- Composite signal
- Components signal
- NTSC and PAL systems
- Sampling of the TV signal
Basic TV system

Real world

Camera

Transmission line

Amplitude

Transmitter

Electrical signal

Visual system

TV screen

Receiver
Human visual system

- Sclera
- Optic nerve
- Blind spot
- Aqueous humor
- Vitreous humor
- Lens
- Fovea
- Retina
- Iris
- Cornea

Graphs:
- Sensitivity to contrast vs. spatial frequency (cycles/degree) and temporal frequency (Hz)
- Glare limit vs. log of intensity
- Subjective brightness vs. adaptation range
Progressive TV system

Number of lines per image:

Depends on desired vertical definition

Number of images per second:

No flicker > 50
Motion sensation > 15
Vertical definition (1)

1 cycle

33.5 cycles per image height
Vertical definition (2)

1 cycle

6.5 cycles per image height
Vertical definition (3)

1 cycle

1.5 cycles per image height
Horizontal definition (1)

1 cycle

33.5 cycles per image width
Horizontal definition (2)

1 cycle

6.5 cycles per image width
Horizontal definition (3)

1 cycle

1.5 cycles per image width
Interlaced TV system (1)

1/60s 1/60s 1/30s
Odd field Even field Complete image

Odd lines Odd field flyback Even lines Even field flyback

Number of lines: 525
Number of images: 30
Number of fields: 60
2 fields = 1 image
Interlaced TV system (2)

Horizontal scanning
Horizontal flyback
Vertical flyback
TV signal - B/W

- Video signal
- Horizontal synchronism
- Maximum level
- Blanking level
- White level
- Line N

Amplitude %
Field synchronism

even

odd
TV signal spectrum - B/W

$h$: Line frequency (15.750)

$v$: Field frequency (60)
TV emitter - B/W

Microphone

Audio Amplif.

FM modulator

Sound carrier

RF Amplif.

Video carrier

Video adder + sync

Sync. generation

AM modulator

Video R.F. Amplif.

Vestigial Lateral band filter

TV camera

Video Amplif.

camara time base
Gamma correction

\[ Y = X^{2.8} \]

\[ Y = X^{1/2.8} \]
Color TV systems

Bandwidth is $3 \times 5 \text{ MHz} = 15 \text{ Mhz}$
Component TV color signals

Camera

\[ Y = 0.30R + 0.59G + 0.11B \]
\[ u = 0.495 (B - Y) \]
\[ v = 0.877 (R - Y) \]

Bandwidth is 7 Mhz

Y - Luminance

u = 0.495 (B – Y)

v = 0.877 (R - Y)
**TV color signals (1)**

R - Y = R - (0.30R + 0.59G + 0.11B) = 0.7R - 0.59G - 0.11B

B - Y = B - (0.30R + 0.59G + 0.11B) = -0.3R - 0.59G + 0.89B

G - Y = -(0.3/0.59)(R - Y) - (0.11/0.59)(B - Y)
### TV color signals (2)

<table>
<thead>
<tr>
<th></th>
<th>White</th>
<th>Gray</th>
<th>Saturated red (very bright)</th>
<th>Saturated red (less bright)</th>
<th>Desaturated red</th>
<th>Saturated green</th>
<th>Saturated blue</th>
<th>Saturated cyan</th>
<th>Saturated magenta</th>
<th>Saturated yellow</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>R</strong></td>
<td>1.0</td>
<td>0.20</td>
<td>1.0</td>
<td>0.5</td>
<td>1.0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td><strong>G</strong></td>
<td>1.0</td>
<td>0.20</td>
<td>0</td>
<td>0</td>
<td>0.5</td>
<td>1.0</td>
<td>0</td>
<td>0</td>
<td>1.0</td>
<td>0</td>
</tr>
<tr>
<td><strong>B</strong></td>
<td>1.0</td>
<td>0.20</td>
<td>0</td>
<td>0</td>
<td>0.5</td>
<td>0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Y</strong></td>
<td>1.0</td>
<td>0.20</td>
<td>0.30</td>
<td>0.15</td>
<td>0.65</td>
<td>0.59</td>
<td>0.11</td>
<td>0.70</td>
<td>0.41</td>
<td>0.89</td>
</tr>
<tr>
<td><strong>R-Y</strong></td>
<td>0</td>
<td>0</td>
<td>0.70</td>
<td>0.35</td>
<td>0.35</td>
<td>0.59</td>
<td>-0.11</td>
<td>0.70</td>
<td>-0.59</td>
<td>0.11</td>
</tr>
<tr>
<td><strong>G-Y</strong></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.41</td>
<td>-0.11</td>
<td>0.30</td>
<td>-0.59</td>
<td>0.11</td>
<td>-0.41</td>
</tr>
<tr>
<td><strong>B-Y</strong></td>
<td>0</td>
<td>0</td>
<td>-0.30</td>
<td>-0.15</td>
<td>-0.15</td>
<td>-0.59</td>
<td>0.89</td>
<td>0.30</td>
<td>0.59</td>
<td>-0.89</td>
</tr>
</tbody>
</table>
NTSC defines

\[ I = 0.877 (R - Y) \cos 33 - 0.493 (B - Y) \sin 33 \]
\[ Q = 0.877 (R - Y) \sin 33 + 0.493 (B - Y) \cos 33 \]

I Bandwidth: 1.5 Mhz

Q Bandwidth: 0.5 Mhz

Note: Next slides will use, (I,Q), (u,v) or (R-Y, B-Y) indistinctly. Signals are not exactly the same, but concepts are. There is a weighting factor applied.
Colors and u-v signals

Hue

Red 103°
Yellow 167°
Green 241°
Magenta 61°
Blue 347°
Cyan 283°

saturation

U 0.493 (B-Y)
V 0.877 (R-Y)

0.1 0.2 0.3 0.4 0.5 0.6 0.7

-0.1 -0.2 -0.3 -0.4 -0.5 -0.6 -0.7

Magenta 61°
Blue 347°
Cyan 283°

Amplitude modulation

Subcarrier oscillator

3.58 Mhz

CHROMINANCE

S(t) = I \cos(\omega_s t+33) + Q \sin(\omega_s t+33)
**Chrominance signal**

Luminance signal

Chrominance signal
Composite video signal
Weighted composite video signal

Carrier amplitude

White level

Black level

White
Yellow
Cyan
Cyan
Magenta
Red
Blue
Black

100 %
75 %
20 %
0

1.33
1.2
1.0
0.8
0.6
0.4
0.2
0
-0.2
-0.4
Composite video signal spectrum

- **Y**: Bandwidth depends on (I,Q) signals
- **u, v**: Bandwidth depends on (I,Q) or (u,v) signals

4.43 (color subcarrier - PAL)
3.58 (color subcarrier – NTSC)
\[ S(t) = (B-Y)\sin(\omega_s t) + (R-Y)\cos(\omega_s t) \]

R – Y is switched each line to compensate for the phase errors (hue)
PAL system (2)
Sampling of the TV signal

- Component sampling
  Applications: multimedia, Digital TV

- Composite signal sampling
  Applications at the TV receiver
  Image enhancement
  Flicker reduction
## Component sampling

<table>
<thead>
<tr>
<th></th>
<th>ITU - 601</th>
<th>CIF</th>
<th>QCIF</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sampled signals</strong></td>
<td>Y, u, v</td>
<td>Y, u, v</td>
<td>Y, u, v</td>
</tr>
<tr>
<td><strong>Sampling frequency Mhz.</strong></td>
<td>(Y) 13.5 - (u,v) 6.75</td>
<td>(Y) 6.75 - (u,v) 3.375</td>
<td>(Y) 6.75 - (u,v) 3.375</td>
</tr>
<tr>
<td><strong>Sampling structure</strong></td>
<td>orthogonal 1:1</td>
<td>orthogonal 1:1</td>
<td>orthogonal 1:1</td>
</tr>
<tr>
<td><strong>Pixels / image</strong></td>
<td>(Y): 720 x 576</td>
<td>(Y): 352 x 288</td>
<td>(Y): 176 x 144</td>
</tr>
<tr>
<td></td>
<td>(u,v): 360 x 288</td>
<td>(u,v): 176 x 144</td>
<td>(u,v): 88 x 72</td>
</tr>
<tr>
<td><strong>Bits/pixel</strong></td>
<td>8</td>
<td>8</td>
<td>8</td>
</tr>
</tbody>
</table>